CLAIMS

What is claimed is:

1. An apparatus comprising:

first and second optical filters cascaded together so that the second optical filter filters light output from the first optical filter, the first and second optical filters having filtering characteristics controlled in accordance RF signals applied thereto, wherein a phase of a beat generated by the RF signals applied to the first optical filter is different than a phase of a beat generated by the RF signals applied to the second optical filter.

2. An apparatus as in claim 1, wherein the difference in phase of the beats generated by the RF signals applied to the first and second optical filters is equal to a value obtained by dividing 180° by the number of stages of cascaded optical filters.

3. An apparatus as in claim 1, wherein the first and second optical filters are acousto-optical tunable filters.

4. An apparatus comprising:

first and second acousto-optical tunable filters (AOTF) cascaded together so that the second AOTF filters light output from the first AOTF, the first and second AOTFs having filtering characteristics controlled in accordance with RF signals applied thereto, wherein a phase of a beat generated by the RF signals applied to the first AOTF is different than a phase of a beat generated by the RF signals applied to the second AOTF.

5. An apparatus as in claim 4, wherein the difference in phase of the beats generated by the RF signals applied to the first and second AOTFs is equal to

a value obtained by dividing 180° by the number of stages of cascaded AOTFs.

6. An apparatus comprising:

a first optical filter selectively outputting a light having a wavelength corresponding to an RF signal controlling the first optical filter; and

a second optical filter receiving the light output from the first optical filter and selectively outputting a light having a wavelength corresponding to an RF signal controlling the second optical filter, wherein a phase of a beat generated by the RF signal controlling the first optical filter is different than a phase of a beat generated by the RF signal controlling the second optical filter.

7. An apparatus as in claim 6, wherein the first and second optical filters are acousto-optical tunable filters.

8. An apparatus comprising:

a first optical filter receiving an input light including a plurality of wavelengths and filtering the input light to output a light having a respective wavelength of the plurality of wavelengths and selected in accordance with an RF signal controlling the first optical filter; and

a second optical filter filtering the light output from the first optical filter to output a light having a wavelength selected in accordance with an RF signal controlling the second optical filter, wherein a phase of a beat generated by the RF signal controlling the first optical filter is different than a phase of a beat generated by the RF signal controlling the second optical filter.

9. An apparatus as in claim 8, wherein the first and second optical filters are acousto-optical tunable filters.

10. An apparatus comprising:

a first optical filter filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with RF signals applied to the first optical filter for controlling filtering characteristics of the first optical filter, and the second output light including said selected wavelength;

a second optical filter filtering the first output light in accordance with RF signals applied to the second optical filter for controlling filtering characteristics of the second optical filter; and

a third optical filter filtering the second output light in accordance with RF signals applied to the third optical filter for controlling filtering characteristics of the third optical filter, wherein a phase of a beat generated by the RF signals applied to the first optical filter is different than a phase of a beat generated by the RF signals applied to the second optical filter and a phase of a beat generated by the RF signals applied to the third optical filter.

11. An apparatus as in claim 10, wherein the beats generated by the RF signals applied to the second and third optical filters have the same phase.

12. An apparatus as in claim 10, wherein the second optical filter filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signals applied to the second optical filter.

13. An apparatus as in claim 10, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signals applied to the third optical filter.

14. An apparatus as in claim 12, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signals applied to the third optical filter.

15. An apparatus as in claim 10, wherein

the first output light from the first optical filter excludes at least two wavelengths of the plurality of wavelengths and which are selected in accordance with the RF signals applied to the first optical filter, and

the second output light from the first optical filter includes said selected at least two wavelengths.

16. An apparatus as in claim 10, wherein

the first, second and third optical filters are acousto- optical tunable filters formed on a single substrate,

the substrate has at least one reflecting device thereon, and

the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate so that

the first output light reflects from the first optical filter to the second optical filter to be filtered by the second optical filter, and

the second output light reflects from the first optical filter to the third optical filter to be filtered by the third optical filter.

17. An apparatus as in claim 16, wherein the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate relative to each other so that

the first output light reflecting from the first optical filter to the second optical filter does not reflect back to the first optical filter, and

the second output light reflecting from the first optical filter to the third optical filter does not reflect back to the first optical filter.

18. An apparatus comprising:

a first acousto-optical tunable filter (AOTF) filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with RF signals applied to the first AOTF for controlling filtering characteristics of the first AOTF, and the second output light including said selected wavelength;

a second AOTF filtering the first output light in accordance with RF signals applied to the second AOTF for controlling filtering characteristics of the second AOTF; and

a third AOTF filtering the second output light in accordance with RF signals applied to the third AOTF for controlling filtering characteristics of the third AOTF, wherein a phase of a beat generated by the RF signals applied to the first AOTF is different from a phase of a beat generated by the RF signals applied to the second AOTF and from a phase of a beat generated by the RF signals applied to the third AOTF.

19. An apparatus as in claim 18, wherein the second AOTF filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signals applied to the second AOTF.

20. An apparatus as in claim 18, wherein the third AOTF filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signals applied to the third AOTF.

21. An apparatus as in claim 19, wherein the third AOTF filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signals applied to the third AOTF.

22. An apparatus as in claim 18, wherein

the first output light from the first AOTF excludes at least two wavelengths of the plurality of wavelengths and which are selected in accordance with the RF signals applied to the first AOTF, and

the second output light from the first AOTF includes said selected at least two wavelengths.

23. An apparatus as in claim 18, wherein

the first, second and third AOTFs are formed on a single substrate,

the substrate has at least one reflecting device thereon, and

the first, second and third AOTFs, and the at least one reflecting device, are arranged on the substrate so that

the first output light reflects from the first AOTF to the second AOTF to be filtered by the second AOTF, and

the second output light reflects from the first AOTF to the third AOTF to be filtered by the third AOTF.

24. An apparatus as in claim 23, wherein the first, second and third AOTFs, and the at least one reflecting device, are arranged on the substrate relative to each other so that

the first output light reflecting from the first AOTF to the second AOTF does not reflect back to the first AOTF, and

the second output light reflecting from the first AOTF to the third AOTF does not reflect back to the first AOTF.

25. An apparatus comprising:

a first optical filter filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with an RF signal applied to the first optical filter for controlling filtering characteristics of the first optical filter, and the second output light including said selected wavelength;

a second optical filter filtering the first output light in accordance with an RF signal applied to the second optical filter for controlling filtering characteristics of the second optical filter;

a third optical filter filtering the second output light in accordance with an RF signal applied to the third optical filter for controlling filtering characteristics of the third optical filter; and

a phase controller controlling phases of the RF signals applied to the first, second and third optical filters with respect to each other.

26. An apparatus as in claim 25, wherein the phase controller controls the phases so that a phase of a beat generated by the RF signal applied to the first optical filter is different from a phase of a beat generated by the RF signal applied to the second optical filter and from a phase of a beat generated by the RF signal applied to the third optical filter.

27. An apparatus as in claim 26, wherein the phase controller controls the phases of the RF signals applied to the second and third optical filters to be equal.

28. An apparatus as in claim 26, wherein the second optical filter filters the first output light with filtering characteristics which reject said selected

wavelength, in accordance with the RF signal applied to the second optical filter.

29. An apparatus as in claim 26, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal applied to the third optical filter.

30. An apparatus as in claim 28, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal applied to the third optical filter.

31. An apparatus as in claim 26, wherein:

the second optical filter filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signal applied to the second optical filter,

the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal applied to the third optical filter, and

the apparatus further comprises

a fourth optical filter filtering the filtered, first output light from the second optical filter with filtering characteristics which reject said selected wavelength, in accordance with an RF signal applied to the fourth optical filter for controlling filtering characteristics of the fourth optical filter, and

a fifth optical filter filtering the filtered, second output light from the third optical filter with filtering characteristics which pass said selected wavelength, in accordance with an RF signal applied to the fifth optical filter for controliing filtering characteristics of the fifth optical filter.

32. An apparatus as in claim 31, wherein the phase controller controls phases of the RF signals applied to the first, second, third, fourth and fifth optical filters with respect to each other.

33. An apparatus as in claim 25, wherein

the first, second and third optical filters are formed on a single substrate,

the substrate has at least one reflecting device thereon, and

the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate so that

the first output light reflects from the first optical filter to the second optical filter to be filtered by the second optical filter, and

the second output light reflects from the first optical filter to the third optical filter to be filtered by the third optical filter.

34. An apparatus as in claim 33, wherein the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate relative to each other so that

the first output light reflecting from the first optical filter to the second optical filter does not reflect back to the first optical filter, and

the second output light reflecting from the first optical filter to the third optical filter does not reflect back to the first optical filter.

35. An apparatus comprising:

first and second optical filters cascaded together so that the second optical filter filters light output from the first optical filter, the first and second optical filters having filtering characteristics controlled in accordance with first and second RF signals, respectively, wherein the first RF signal has a different

phase than the second RF signal.

36. An apparatus as in claim 35, wherein a phase of a beat generated by the first RF signal is different than a phase of a beat generated by the second RF signal.

37. An apparatus as in claim 36, wherein the difference in phase of the beats generated by the first and second RF signals is equal to a value obtained by dividing 180° by the number of stages of cascaded optical filters.

38. An apparatus as in claim 35, wherein the first and second RF signals are at the same frequency.

39. An apparatus comprising:

first and second acousto-optical tunable filters (AOTF) cascaded together so that the second AOTF filters light output from the first AOTF, the first and second AOTFs having filtering characteristics controlled in accordance with first and second RF signals, respectively, wherein the first RF signal has a different phase than the second RF signal.

40. An apparatus as in claim 39, wherein a phase of a beat generated by the first RF signal is different than a phase of a beat generated by the second RF signal.

41. An apparatus as in claim 40, wherein the difference in phase of the beats generated by the first and second RF signals is equal to a value obtained by dividing 180° by the number of stages of cascaded AOTFs.

42. An apparatus as in claim 39, wherein the first and second RF signals are at the same frequency.

43. An apparatus comprising:

a first optical filter selectively outputting a light having a wavelength corresponding to an RF signal controlling the first optical filter; and

a second optical filter receiving the light output from the first optical filter and selectively outputting a light having a wavelength corresponding to an RF signal controlling the second optical filter, wherein a phase of the RF signal for controlling the first optical filter is different than a phase of the RF signal for controlling the second optical filter.

44. An apparatus as in claim 43, wherein the first and second optical filters are acousto-optical tunable filters.

45. An apparatus as in claim 43, wherein a phase of a beat generated by the RF signal controlling the first optical filter is different than a phase of a beat generated by the RF signal controlling the second optical filter.

46. An apparatus as in claim 43, further comprising:

a phase shifter causing the phase of the RF signal controlling the first optical filter to be different than a phase of the RF signal controlling the second optical filter.

47. An apparatus as in claim 43, wherein the RF signal controlling the first optical filter is at the same frequency as the RF signal controlling the second optical filter.

48. An apparatus comprising:

a first optical filter receiving an input light including a plurality of wavelengths and filtering the input light to output a light having a respective wavelength of the plurality of wavelengths and selected in accordance with an RF signal controlling the first optical filter; and

a second optical filter filtering the light output from the first optical filter to output a light having a wavelength selected in accordance with an RF signal controlling the second optical filter, wherein a phase of the RF signal for controlling the first optical filter is different than a phase of the RF signal for controlling the second optical filter.

49. An apparatus as in claim 48, wherein the first and second optical filters are acousto-optical tunable filters.

50. An apparatus as in claim 48, wherein a phase of a beat generated by the RF signal controlling the first optical filter is different than a phase of a beat generated by the RF signal controlling the second optical filter.

51. An apparatus as in claim 48, further comprising:

a phase shifter causing the phase of the RF signal controlling the first optical filter to be different than a phase of the RF signal controlling the second optical filter.

52. An apparatus as in claim 48, wherein the RF signal controlling the first optical filter is at the same frequency as the RF signal controlling the second optical filter.

53. An apparatus comprising:

a first optical filter filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with an RF signal controlling filtering characteristics of the first optical filter, and the second output light including said selected wavelength;

a second optical filter filtering the first output light in accordance with an RF signal controlling filtering characteristics of the second optical filter; and

a third optical filter filtering the second output light in accordance with an RF signal controlling filtering characteristics of the third optical filter, wherein the RF signals controlling filtering characteristics of the second and third optical filters each have a different phase than that of the RF signal controlling filtering characteristics of the first optical filter.

54. An apparatus as in claim 53, wherein the RF signals for controlling filtering characteristics of the second and third optical filters have the same phase.

55. An apparatus as in claim 53, wherein the second optical filter filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signal controlling the second optical filter.

56. An apparatus as in claim 53, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third optical filter.

57. An apparatus as in claim 55, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third optical filter.

58. An apparatus as in claim 53, wherein the RF signals controlling the first, second and third optical filters are at the same frequency.

59. An apparatus as in claim 53, wherein the first, second and third optical filters are acousto-optical tunable filters.

60. An apparatus as in claim 53, wherein

the first, second and third optical filters are formed on a single substrate,

the substrate has at least one reflecting device thereon, and

the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate so that

the first output light reflects from the first optical filter to the second optical filter to be filtered by the second optical filter, and

the second output light reflects from the first optical filter to the third optical filter to be filtered by the third optical filter.

61. An apparatus as in claim 60, wherein the first, second and third optical filters, and the at least one reflecting device, are arranged on the substrate relative to each other so that

the first output light reflecting from the first optical filter to the second optical filter does not reflect back to the first optical filter, and

the second output light reflecting from the first optical filter to

the third optical filter does not reflect back to the first optical filter.

62. An apparatus comprising:

a first acousto-optical tunable filter (AOTF) filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with an RF signal controlling filtering characteristics of the first AOTF, and the second output light including said selected wavelength;

a second AOTF filtering the first output light in accordance with an RF signal controlling filtering characteristics of the second AOTF; and

a third AOTF filtering the second output light in accordance with an RF signal controlling filtering characteristics of the third AOTF, wherein the RF signals controlling filtering characteristics of the second and third AOTFs each have a different phase than that of the RF signal controlling filtering characteristics of the first AOTF.

63. An apparatus as in claim 62, wherein the RF signals for controlling filtering characteristics of the second and third AOTFs have the same phase.

64. An apparatus as in claim 62, wherein a phase of a beat generated by the RF signals controlling filtering characteristics of the second and third AOTFs is different than a phase of a beat generated by the RF signal controlling filtering characteristics of the first AOTF.

65. An apparatus as in claim 62, wherein the RF signals controlling filtering characteristics of the first, second and third AOTFs are at the same frequency.

66. An apparatus as in claim 62, wherein the second AOTF filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signal controlling the second AOTF.

67. An apparatus as in claim 62, wherein the third AOTF filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third AOTF.

68. An apparatus as in claim 66, wherein the third AOTF filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third AOTF.

69. An apparatus as in claim 62, wherein

the first, second and third AOTFs are formed on a single substrate,

the substrate has at least one reflecting device thereon, and

the first, second and third AOTFs, and the at least one reflecting device, are arranged on the substrate so that

the first output light reflects from the first AOTF to the second AOTF to be filtered by the second AOTF, and

the second output light reflects from the first AOTF to the third AOTF to be filtered by the third AOTF.

70. An apparatus as in claim 69, wherein the first, second and third AOTFs, and the at least one reflecting device, are arranged on the substrate relative to each other so that

the first output light reflecting from the first AOTF to the second AOTF does not reflect back to the first AOTF, and

the second output light reflecting from the first AOTF to the

third AOTF does not reflect back to the first AOTF.

71. An apparatus comprising:

a first optical filter filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with an RF signal controlling filtering characteristics of the first optical filter, and the second output light including said selected wavelength;

a second optical filter filtering the first output light in accordance with an RF signal controlling filtering characteristics of the second optical filter;

a third optical filter filtering the second output light in accordance with an RF signal controlling filtering characteristics of the third optical filter; and

a phase controller controlling phases of the RF signals controlling filtering characteristics of the first, second and third optical filters with respect to each other.

72. An apparatus as in claim 71, wherein the phase controller controls the phases so that the phases of RF signals controlling filtering characteristics of the first and second optical filters are different than the phase of the RF signal controlling filtering characteristics of the first optical filter.

73. An apparatus as in claim 72, wherein the phase controller controls the phases of the RF signals for controlling filtering characteristics of the second and third optical filters to be equal.

74. An apparatus as in claim 71, wherein the RF signals for controlling filtering characteristics of the first, second and third optical filters are at the same frequency.

75. An apparatus as in claim 71, wherein the second optical filter filters the first output light with filtering characteristics which reject said selected wavelength, in accordance with the RF signal controlling the second optical filter.

76. An apparatus as in claim 71, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third optical filter.

77. An apparatus as in claim 75, wherein the third optical filter filters the second output light with filtering characteristics which pass said selected wavelength, in accordance with the RF signal controlling the third optical filter.

78. An apparatus comprising:

a first optical filter receiving an input light including a plurality of wavelengths and filtering the input light to output a light having at least two wavelengths of the plurality of wavelengths and selected in accordance with RF signals controlling the first optical filter, the RF signals including at least two RF signals corresponding, respectively, to the selected at least two wavelengths and having frequencies suitable for causing the first optical filter to select the corresponding wavelengths; and

a second optical filter filtering the light output from the first optical filter to output a light having wavelengths selected in accordance with RF signals controlling the second optical filter, the RF signals controlling the second optical filter including at least one RF signal having a frequency which is the same as, but having a phase which is different than, that of an RF signal

controlling the first optical filter.

79. An apparatus as in claim 78, wherein the first and second optical filters are acousto-optical tunable filters.

80. An apparatus comprising:

a plurality of acousto-optical tunable filters (AOTF) cascaded together, each AOTF generating a surface acoustic wave in an optical waveguide in accordance with an RF signal applied to the AOTF to selectively output a light having a wavelength corresponding to the RF signal, wherein a phase of a beat generated by the RF signal applied to one of the plurality of AOTFs is different from a phase of a beat generated by the RF signal applied to a different AOTF of the plurality of AOTFs.

81. An apparatus comprising:

a first optical filter filtering an input light including a plurality of wavelengths to output first and second output lights, the first output light excluding a wavelength of the plurality of wavelengths selected in accordance with an RF signal applied to the first optical filter for controlling filtering characteristics of the first optical filter, and the second output light including said selected wavelength;

a second optical filter filtering the first output light with filtering characteristics which reject said selected wavelength in accordance with an RF signal applied to the second optical filter for controlling filtering characteristics of the second optical filter;

a third optical filter filtering the second output light with filtering characteristics which pass said selected wavelength in accordance with an RF signal applied to the third optical filter for controlling filtering characteristics

of the third optical filter;

a fourth optical filter filtering the filtered, first output light from the second optical filter with filtering characteristics which reject said selected wavelength in accordance with an RF signal applied to the fourth optical filter for controlling filtering characteristics of the fourth optical filter;

a fifth optical filter filtering the filtered, second output light from the third optical filter with filtering characteristics which pass said selected wavelength in accordance with an RF signal applied to the fifth optical filter for controlling filtering characteristics of the fifth optical filter; and

a phase controller controlling phases of the RF signals applied to the first, second, third, fourth and fifth optical filters with respect to each other.

82. An apparatus as in claim 81, wherein the phase controller controls the phases so that

the phase of the RF signal applied to the first optical filter is different from the phases of the RF signals applied to the second, third, fourth and fifth optical filters.

83. An apparatus as in claim 82, wherein the phases of the RF signals applied to the second and third optical filters are equal, and the phases of the RF signals applied to the fourth and fifth optical filters are equal.

84. An apparatus as in claim 81, wherein the first, second, third, fourth and fifth optical filters are acousto-optical tunable filters.

85. An apparatus as in claim 82, wherein the first, second, third, fourth and fifth optical filters are acousto-optical tunable filters.

86. A method comprising:

cascading first and second optical filters together so that the second optical filter filters light output from the first optical filter, the first and second optical filters having filtering characteristics controlled in accordance RF signals applied thereto; and

causing a phase of the RF signal applied to the first optical filter to be different than a phase of the RF signal applied to the second optical filter.

87. A method as in claim 86, wherein a phase of a beat generated by the RF signal applied to the first optical filter is different than a phase of a beat generated by the RF signal applied to the second optical filter.

88. A method comprising:

cascading first and second optical filters together so that the second optical filter filters light output from the first optical filter, the first and second optical filters having filtering characteristics controlled in accordance RF signals applied thereto; and

causing a phase of a beat generated by the RF signals applied to the first optical filter to be different than a phase of a beat generated by the RF signals applied to the second optical filter.

89. An optical communication system comprising:

a transmission line;

a transmitter transmitting a wavelength division multiplexed (WDM) signal including a plurality of channels through the transmission line;

a receiver receiving the transmitted WDM signal through the transmission line; and

an optical filtering apparatus filtering the WDM signal as the WDM

signal travels through the transmission line from the transmitter to the receiver to selectively filter at least one channel from the WDM signal, the optical filtering apparatus including

first and second acousto-optical tunable filters (AOTF) cascaded together so that first AOTF filters the WDM signal and produces a corresponding filtered output light, and the second AOTF filters the filtered output light from the first AOTF, the first and second AOTFs having filtering characteristics controlled in accordance with first and second RF signals, respectively, wherein the first RF signal has a different phase than the second RF signal.